Situation-Interpretation as a key enabler for cost-effective and low-risk driver assistance systems with high collision mitigation capabilities

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Abstract

In the area of safety-oriented driver assistance systems there is a trend to increase the accident mitigation capabilities by adding or strengthening autonomous system reactions. However, this also increases the potential for involuntary accidents in the case of malfunction. Due to product liability regulations these high risk functions require an increased development effort as well as more reliable sensor platforms, which drive up their costs.

The accident mitigation capabilities of autonomously acting systems can also be achieved by an alternative strategy avoiding the high risk system reactions. The key is an early and reliable warning giving the driver time to react to the situation, combined with functions supporting the driver in his reactions, e.g. emergency braking.

Early system reactions with low false activation rates can only be achieved by an advanced understanding of the traffic situation and an interpretation of the driver's actions in this context. To achieve this, the traditional approach of assessing the criticality of one potential collision object is extended towards observing and assessing multi-object scenarios. An analysis of accident statistics shows that in a high percentage of accidents the multi-object constellation provides additional information enabling early criticality assessments of the traffic situation. Using this information, the driver can be supported in an optimal way by an early, low-risk system reaction.

This approach is the key for the vision "safety for everybody", i.e. providing cost-effective collision mitigation functions with high collision mitigation capabilities to the mass market.

1. Risk Assessment

In the area of safety-oriented driver assistance systems there is a trend to increase the accident mitigation capabilities by adding or strengthening autonomous system reactions. The functions have to satisfy safety-standards like e.g. the ISO 26262 demanding for a risk and hazard analysis.

The approach to assess the "criticality in case of malfunction" of e.g. a fully autonomous emergency braking function used at Bosch is a model-based so-called objectified danger and risk analysis. In this, the effect of a false triggering of a specified autonomous emergency braking function is simulated on the basis of real traffic data, e.g. distances and relative velocities between vehicles. The analysis shows that the more velocity an autonomous braking function can reduce in a short time, the higher their damage potential is, i.e. the more often and the more severe rear-end accidents are caused. The ISO 26262 demands that functions with high damage potential must satisfy a low rates of malfunction. Technically this is possible by means of the following measures: robust and therefore in tendency expensive sensors or sensor clusters (i.e. sensor-costs with respect to the function portfolio they cover); development processes and hardware that comply with ISO 26262 damage-potential rating (aSIL) standards; extensive endurance test drives to proof the compliance with false activation rates demanded by safety analysis.

In contrast, a concept putting the responsibility for triggering an autonomous intervention to the driver results in much lower demands on the false activation rates. Crucial for the category of the functions which warn and then assist the driver is that they are only activated if besides the environment sensors the activities of the driver also indicate a critical situation. This reduces the requirements to the reliability of situation interpretation by the environment sensors and the in tendency costly measures listed above are not necessary. These functions are state of the art. However, their

effectiveness – i.e. the accident prevention capabilities - can be greatly increased if the warning is set to an earlier point in time giving the driver more time to react; because of the possibility of evading or a full stop, the driver has more effective methods for accident prevention than an autonomously braking system with restricted deceleration. This all is possible without an increase of the damage potential of the function.

In a generalized manner it can be summed up: The stronger and potentially more risky the intervention of an autonomous function, the more expensive the development, safeguarding and hardware of the function. In most situations though an early warning with driver assisting functions without risky autonomous interventions is similarly or more effective and can be realized on the basis of a cheaper sensor. By means of such economical systems, so the vision, access to a safety-oriented driver assistance is to be made possible for every road-user.

2. Increasing Benefit by Situational Interpretation

Key of the realization of a cheap but effective driver assistance function covering the front collision case is the realization of an early warning, i.e. an early and reliable criticality-assessment of the traffic situation. The dilemma that an earlier warning to a critical traffic situation typically also drastically increases the false warning rates is well known. To achieve an earlier warning at constant false-alarm level the following strategy is chosen:
For situational interpretation additional information arises from the observation of the traffic situation of third party road-users. If critical situations are detected for third party vehicles, a behavior deviating from the normal case is to be expected from them. For example, if a faster vehicle approaches a slower vehicle on the left lane, the probability increases that the fast vehicle will pull out onto the lane of the own vehicle and that as a result there will be a critical situation for a third party vehicle. This simple example shows that functions which only use one "target object" are restricted in the quality of the criticality assessment as a result of their principle.
Basis of the analysis of the benefit of multi-object scenarios is a detailed accident analysis of the GIDAS-accident database in individual case representation. Observed are accidents in longitudinal traffic (GIDAS-accident type 6) and accidents while turning off (GIDAS-accident type 2). Altogether, the area of effect of a driver assistance function reacting to frontal and parallel traffic therefore is approximately 20% of the complete incidence of accidents. The accidents within this area of effect were analyzed and classified according to the additional information available by additional objects. For two of classes, the additional benefit by evaluation of the multi-object information is discussed in the following. The information in percentages relates to the area of effect of approximately 20 %.

Case 1: In 9.3 % of the accidents, the preceding vehicle brakes strongly while there is oncoming traffic on the left lane. If only the "target object" is observed, the driver assistance system as a matter of principle has the problem of the decision between evading and braking. This is correspondent to the second problem of decision (warning dilemma) discussed in section 2. But when there is oncoming traffic, overtaking respectively evading can be excluded as a sensible option for action for the driver at the time of warning. This is the basis to realize an earlier and more reliable system assessment / reaction is possible.

Case 2: In 10.5 % of the accidents, the preceding vehicle drives against a slower object and brakes strongly. In principle, radar based driver assistance systems can detect pre-preceding vehicles. Before the actual target object becomes "a problem" in this example because of its strong braking, it is possible to discern a critical traffic situation for the preceding vehicle by observing its fast approach to the vehicle in front of it. The hypothesis that the preceding vehicle will brake or evade to prevent the accident is self-evident. On the basis of this interpretation, the behavior modeling for the preceding vehicle can be adjusted to already warn the driver with this before it is even possible to detect the danger by means of the state of the "target object". The described situation is especially important for a driver, because his view on the pre-preceding vehicle is obstructed. The driver assistance system however has its radar measurement and therefore an advantage in information compared to the driver.

3 Summary

By the assessment of multi-object scenarios, an earlier and more reliable criticality assessment of a traffic situation is possible for many frontal accidents. This can be used to distinctly increase the effectiveness of low-risk driver assistance functions. By combining early driver warning with driver assisting functions, it is possible to reach, relating to the total number of frontal accidents, the effectiveness of functions with strong autonomous intervention. The argument is essentially based on the experience that with "target object based" driver

assistance systems, the obscurity about how a situation will progress increases drastically with growing temporal range of prediction, and that this can be moderated by the additional involvement of multi-object information.

The early warning approach illustrated by Bosch offers the advantage that it is possible to forego the use of complex, expensive and strongly autonomously intervening systems. The great benefit combined with the low price is the basis of the vision to make safety oriented driver assistance functions with high effectiveness available to the mass market.

Reference

[1] J. Häring, U. Wilhem, W. Branz: „Entwicklungsstrategie für das Niedrigpreis-Segment", Automobiltechnische Zeitschrift (ATZ), März 2009